

THE OSTEOLOGY AND RELATIONSHIP OF THE PERCOIDEAN FISH, *DINOLESTES LEWINI*.

By EDWIN CHAPIN STARKS,

Assistant Professor in the Department of Biology and Curator of the Museum, University of Washington, Seattle, Washington.

As a preliminary to this paper I will quote a paragraph from a paper by Dr. Theodore Gill, "On the identity of *Esox lewini* with the *Dinolestes mülleri* of Klunzinger," published about twenty-five years ago in the *Annals and Magazine of Natural History*. In it he gives the following concise history of *Dinolestes*:

In the tenth volume ("the class Pisces") of the "Animal Kingdom" of Cuvier, edited by Edward Griffith (1834), are a figure (plate 60) and a brief notice (p. 465) of a fish which has long been a puzzle to me. It is called *Esox lewini* and only noticed as follows: "Our figure of *Esox lewini* is from a drawing by Mr. Lewin, made in New Holland, of a species not hitherto noticed." It was evident that the species thus named belonged neither to the genus *Esox* nor anywhere near it; and (1) the relations of the fins, (2) the position of the ventrals with a spine and five rays each, (3) the form of the head, and (4) the teeth indicated for it affinity to *Chilodipterus* and allied forms; but no first dorsal fin was represented. The question then arose whether that fin had been atrophied (as in *Aspidophoroides*, *Gobiopus*, etc.) or (as was more likely) had been overlooked. After nearly forty years the species has been recovered, and singularly enough, after having escaped the observation of the numerous collectors in the Australian seas for so long a time,¹ has in the same year been obtained and described by three different naturalists under as many names, viz, *Dinolestes mülleri* by Klunzinger, *Neosphyraena multiradiata* by Castelnau, and *Lanioperca mordax* by Günther. There can be no question about at least the generic identity of the *Esox lewini* with the fishes described by the three contemporaries; and it now appears that the first dorsal fin exists, but is quite small, and sustained by only four or five spines. Klunzinger and Castelnau refer the type to the family Sphyrenidæ, and Günther (with more justification I think) to the "Apogonina," i. e., Chilodipteridæ.

This work was undertaken at Dr. Gill's suggestion in the hope of finding, in a comparative study of the skeleton of *Dinolestes* with those of the Sphyrenidæ and the Cheilodipteridæ, some characters that

¹ It is said, however, by Castelnau to be common [at Melbourne] in the months of May, June, and July; it attains 2 feet in length. The fishermen call it "Ship Jack," but that name is more particularly applied to *Temnodon saltator*.

would decide the question on which the authorities disagreed, as shown in the last sentence quoted from the above paper.

It would appear an easy matter to place this form under one or the other of two families arranged in different suborders, as the Sphyrænidæ and Cheilodipteridæ usually are: but the fact that two of the authorities consider it under one family and two under the other, indicates how close the resemblance must be to either.

Sphyræna argentea is the form chosen to represent the family Sphyrænidæ, while the only representative procurable of the Cheilodipteridæ was *Apogon maculatus*.

The skeleton of *Apogon* was found to be of but little assistance in this comparison. Though being undoubtedly Percoid, it differs as much from *Dinolestes* as they both differ from the more generalized Percoids, such as the bass or perch. Considering the difference between *Dinolestes* and *Apogon* in external appearance, we have probably little reason to expect the internal resemblance to be otherwise. Perhaps if one of the *Sphyræna*-like Cheilodipteroids could be examined there would be a closer resemblance.

To be sure *Dinolestes* differs from *Apogon* only in shape and comparative size of elements (that is, comparative between corresponding elements of each species), and not in arrangement, or lack or possession of elements; but it is so very different in shape of cranium, form of body, and shape of fins that it would seem better to consider the Cheilodipteroid side of the question partly by considering the Percoid fishes more or less as a whole. Though, of course, if it is placed with the Percoids it is only under the family Cheilodipteridæ, as the Percoids are now arranged, that *Dinolestes* could be admitted.

Were it not that the ventrals of *Dinolestes* are apparently thoracic, it might appear after a superficial external examination to be related to *Sphyræna*. The long head, projecting lower jaw, fanglike teeth, and elongate preorbital region are very *Sphyræna*-like. The shape of the body and dorsal fins are also suggestive of that relationship.

In internal characters we find that the ethmoid is wide and flat, somewhat overlying the vomer and prefrontals instead of being interposed between them. This is the condition found in *Sphyræna*. The nasals are very much like those of *Sphyræna*, being long and channeled and attached by their sides to the ethmoid for nearly their whole length. This, however, is probably caused by the elongate snout, and goes with it as a part in keeping with the surrounding conditions. It disposes of the characters by which an alliance with *Sphyræna* could be proved.

Though the shape of the body and head, the canine teeth, and dorsal fins exhibit perhaps a closer superficial resemblance to the Sphyrænidæ than to the Cheilodipteridæ, there are forms to be found in the latter family which approach this *Sphyræna*-like appearance also. These characters therefore denote nothing in favor of either relationship. The characters of the ethmoid and nasals are the only characters possessed by *Sphyræna* in common with *Dinolestes* that are not also shared

in by members of the family Cheilodipteridæ. They are of no great importance.

This, as has been said, is without considering the position of the ventrals. As the Percoid fishes have thoracic ventrals, and the members of the suborder Percesoces, under which the Sphyrenidæ is placed, have abdominal ventrals, it is difficult to see how *Dinolestes* could have been thought to be related to *Sphyrena* unless the ventrals were interpreted as being abnormally anterior abdominal ventrals. The ventrals, however, prove to be typical thoracic ventrals with the anterior point of the pelvic girdle interposed and attached between the opposing clavicles near their lower end above their symphysis. Anterior abdominal ventrals might have the point of the pelvic girdle touching the clavicles or even extending slightly under them, but never interposed between them.

Another character that refutes the Sphyrenoid relationship of *Dinolestes* is the lack of the long processes developed backward from the epiotics and supraoccipital crest, which are possessed in a greater or less degree by all the Percesoces and reaches its greater development in *Sphyrena*.

A more important difference is the structure of the teeth. Though both *Dinolestes* and *Sphyrena* have large backward-directed canines, they are entirely different in the way in which they are attached to the bone of the jaw. The calcified tooth substance of the teeth of *Dinolestes* reaches only to the bone, where it is ankylosed or so incorporated with the bone as to make it difficult to distinguish the line of junction. This attachment is effected by what Tomes calls "bone of attachment." A substance resembling cement, but unlike true cement, is developed from the periosteum rather than from the dental capsule. Such teeth may be developed from sockets, but as the calcified tooth substance is pushed out the cavity behind fills with the bone of attachment and becomes obliterated. The dentine never extends into a cavity of the bone in the mature tooth. This is a Percoid character.

The teeth of *Sphyrena*, on the other hand, are set in sockets. The attachment of teeth in alveoli is of such rare occurrence among fishes and must be so deep seated that we can hardly interpret it as less than a family character. Mr. W. G. Ridewood, in a paper,¹ has this to say in regard to this class of teeth:

The tooth and bone are in organic continuity by means of a periosteal layer common to the tooth and the jaw; and this layer may remain uncalcified so that the teeth can be pulled out of their sockets, as in some Caracinoid fishes; or "bone of attachment" may, except in young teeth, ankylose the tooth to the wall of the socket, e. g., *Sphyrena*.

But whether or not the tooth becomes cemented in, the enamel and dentine extend into a cavity and do not become incorporated with the bone.

¹Natural Science, VIII, June, 1896, p. 383.

There is also a difference in the shape of the teeth of *Sphyræna* and *Dinolestes*. Those of the former are lancelike—that is, compressed laterally and with cutting edges. Those of the latter are round in transverse section.

The vertebræ of *Dinolestes* are typical, or in general resembling the Percoids and most bony fishes in that they are of moderate length and not much constricted in the middle. They have parapophyses developed behind the fourth vertebra, two pits on the side of each vertebra separated by a longitudinal ridge, and the abdominal vertebræ with a pit on the ventral side with ridges on each side of it. The vertebræ of *Sphyræna* are long and smooth with scarcely any pits, much constricted in the middle, making them hourglass shaped, and with only one or two pairs of parapophyses.

The shape of the cranium of *Dinolestes* is also more typically Percoid in appearance than Sphyrænoid with the slightly rising supraoccipital crest and more wedge-shaped lateral view.

A recapitulation with these points condensed will show at once the affinity of *Dinolestes* to the Cheilodipteridæ.

1. The Percoid appearing cranium.
 2. The thoracic ventrals.
 3. The anchylosed teeth rather than teeth in sockets.
 4. The character of the vertebræ, typical; not specialized as in *Sphyræna*.
 5. The lack of the long posterior processes from the epiotics.
- These conclusions are fortified by the following description.

DINOLESTES LEWINI.

- Esox lewini* GRIFFITH (?), Cuvier's Animal Kingdom, Griffith ed., X (1834), p. 465, pl. 60.
- Dinolestes mülleri* KLUNZINGER, Archiv für Nat., 38. Jahrg. I (1872), p. 30; Hobson Bay, South Australia.
- Neosphyræna multiradiata* CASTELNAU, Proc. Zool. and Acclim. Soc. Victoria, I (1872), p. 96; Melbourne.
- Lanioperca mordax* GÜNTHER, Ann. and Mag. Nat. Hist., 4th ser., X, (September, 1872), p. 183; Tasmania.
- Dinolestes lewini* GILL, Ann. and Mag. Nat. Hist., 4th ser., XIV (1874), p. 160.

DIAGNOSIS.

Body rather elongate; preorbital region produced; mouth large, the lower jaw projecting; canine teeth on lower jaw posteriorly and on premaxillaries at their symphysis; sharp, cardiform teeth in a single row on jaws, vomer and palatines; an inner row of villiform teeth on premaxillaries; three toothed superior pharyngeals; lower pharyngeals rather narrow, separate; gill rakers long and slender, about 4 + 13; opercles without spines or ridges; branchiostegals 7; maxillary with supplemental bone; nasals elongate, attached by their sides for nearly their whole length; parietals separated; ethmoid somewhat overlying prefrontals and vomer; posttemporal forked; postelavicle of two parts;

basisphenoid with a descending process; myodome present with a small pore to the exterior posteriorly; no suborbital shelf; vertebræ 27; parapophyses present on all abdominal vertebræ except first 3; scales cycloid; maxillaries, cheeks, opercles, and lower jaw with scales; lateral line straight, running well out on base of caudal, scales along its course systematically crowded; base of anal, soft dorsal, and caudal with small scales; anal with 2 spines and about 26 rays; dorsals remote, the first of about 5 slender spines, the second with 1 spine and about 18 rays; ventrals with 1 spine and 5 rays each; interspinous bones not extending between vertebral spines.

OSTEOLOGY.

Cranium, as viewed from above, rather elongate and narrow. Interorbital region a flattish area with the sides nearly parallel the greater part of its length, occupying at least a third of length of cranium. Preorbital region elongate, not tapering till near end, occupying another third of length of cranium. Region surrounding foramen magnum slightly produced. Lateral view of cranium tapering rather regularly to vomer.

Supraoccipital interposed between exoccipitals nearly to their posterior ends; its crest developed superiorly and posteriorly, scarcely extending past exoccipitals posteriorly.

Exoccipitals broadly meeting above basioccipital, entirely surrounding foramen magnum.

Parietals widely separated by supraoccipital, not extending over epiotics.

Epiotics with scarcely any process.

Prootics, opisthotics, sphenotics, and pterotics typical; that is, Percoid-like.

Alisphenoids widely separated. The anterior opening into brain case large.

Basisphenoid present; a foramen between it and basis cranii. A slender process descending from it and attached to parasphenoid.

Myodome present; opening to the exterior at its posterior end through an extremely small foramen.

Parasphenoid spreading out wide posteriorly.

Vomer bearing sharp short teeth in a single row around its anterior edges. Teeth becoming smaller anteriorly.

Prefrontals large and rather elongate, the olfactory foramen scarcely behind middle.

Ethmoid entirely superior to prefrontals and vomer, widely overlying them and extending to edge of rostrum. A raised area along its middle.

Nasals thin elongate rods of bone attached by their sides to ethmoid for nearly their whole length; their length over a fourth that of cranium.

Preorbital longer than wide; its outline triangular.

Suborbital ring of the usual number of five bones with a sensory canal through them. No suborbital shelf.¹

Opercle without ridges or spines on outer surface. On inner surface a sharp horizontal ridge runs posteriorly from its condyle with hyomandibular.

Subopercle extending around lower corner of opercle, upward and backward, forming lower part of posterior opercular angle.

Interopercle very broadly attached to subopercle at its upper posterior side.

Preopercle with ridge and sensory canal as usual.

Lower limb of hyomandibular rather long and rod-like.

Palato-pterygoid process very long and stout. A single row of small teeth along lower edge extending anteriorly upon a process beyond main part of palatine somewhat similar to the usual process from upper edge of that bone. Suspensorium otherwise typical.

Lower jaw heavy and long. The articular half as wide as long. Teeth in a single row upon dentary, three or four canines present posteriorly.

Angular present, rather small.

Maxillary with long supplemental bone along posterior edge.

Premaxillary rather slender, much widened at middle into a wide process which extends behind maxillary; its lower end very slender. A single row of elongate pointed or small canine teeth along its edge, largest medially, growing gradually smaller toward each end. Inside of this row a villiform band, widest medially. At upper end of each maxillary are two large canines ankylosed immovably, the posterior pair much hooked back.

Clavicle and hypercoracoid typical, or as in the Percoids.

Hypocoracoid as usual broadly joined at upper end to clavicle and hypercoracoid, thence arching away and touching lower end of clavicle again with a rather slender process. Besides this, from its middle, running through the usual interspace between it and clavicle, is another process flat and thin, but strengthened through its middle, reaching to and joined to clavicle.

Actinosts four, rather short.

Pectoral not nearer upper end of clavicle than is usual in the Percoids, its upper ray working directly upon hypercoracoid.

Postclavicle in two parts, the inferior very long.

Supraclavicle of moderate length.

Post-temporal widely forked; its articulation with skull typical.

Inferior hypohyal scarcely visible on outer surface of hyoid arch, being covered by superior hypohyal, which forms the greater part of front of arch. Hypohyals of about equal size on inner surface of arch.

Ceratohyals, ephyals, and interhyals typical.

¹Suborbital shelf: a small shelf of bone extending inward from the suborbital ring and conforming to the rotundity of the eyeball. Possessed by many of the higher bony fishes.

Branchiostegals seven, four being borne by ceratohyal and three by epihyal; the three anterior ones attached to inner surface of hyoid arch.

Glossohyal wide, flat, or slightly concave above.

Urohyal elongate, thin, without double heel below, except at extreme anterior end.

Basibranchials three—the first not supporting any arch, the second supporting the first arch, and to the third the second and third arches are joined. No ossified basibranchial to fourth arch.

Epibranchials of third arch meet behind last basibranchial; epibranchials of fourth arch absent.

Suspensory pharyngeals present on first arch.

Superior pharyngeals three in number, that is, on second, third, and fourth arches; the second largest, and with the third forming an elongate patch.

First two interspinal rays of dorsal and of anal not coalesced. None of the interspinals interposed between neural or hæmal spines.

The interval between first and second dorsals occupied by two free auxiliary interneural spines.

First interhæmal spine not enlarged or in any way differentiated from its fellows. Interhæmals equally graduated from behind forward.

Ventral fins truly thoracic. The pelvic girdle long and tapering to a slender point, which is interposed between the clavicles above their union.

The vertebral column composed of 10 abdominal and 16 caudal, which, with the usual hypural, number 27 vertebræ.

Superior zygapophyses both posteriorly and anteriorly present, but small, as is usual in the Percoid fishes.

Inferior zygapophyses well developed posteriorly near middle of column; anteriorly scarcely discernible.

Parapophyses developed on fourth and succeeding abdominal vertebræ, growing larger posteriorly; the last pair connected near their bases by a bridge of bone.

Hypural assisted in supporting caudal fin by spines from two preceding vertebræ.

Ribs and epipleurals typical.

EXPLANATION OF PLATES.

[Drawn by Chloe Lesley Starks.]

Plates VIII, IX, and X, superior, lateral, and posterior views of the cranium of *Dinolestes lewini*, skeleton No. 47877, U.S.N.M., from Port Jackson, Australia.

Plate XI, *Dinolestes lewini*, No. 47929, U.S.N.M., from Tasmania.

SIGNIFICANCE OF REFERENCE LETTERS USED ON PLATES.

<i>als.</i> Alisphenoid.	<i>p.</i> Parietal.
<i>bas.</i> Basisphenoid.	<i>pas.</i> Parasphenoid.
<i>bo.</i> Basioccipital.	<i>pf.</i> Prefrontal.
<i>e.</i> Ethmoid.	<i>pro.</i> Prootic.
<i>eo.</i> Exoccipital.	<i>pto.</i> Pterotic.
<i>epo.</i> Epiotic.	<i>so.</i> Supraoccipital.
<i>fr.</i> Frontal.	<i>spo.</i> Sphenotic.
<i>opo.</i> Opisthotic.	<i>v.</i> Vomer.